Institut
Mines-Telecom

TII - Image Processing and Understanding

Florence Tupin

TSI Department

Team Description

People:

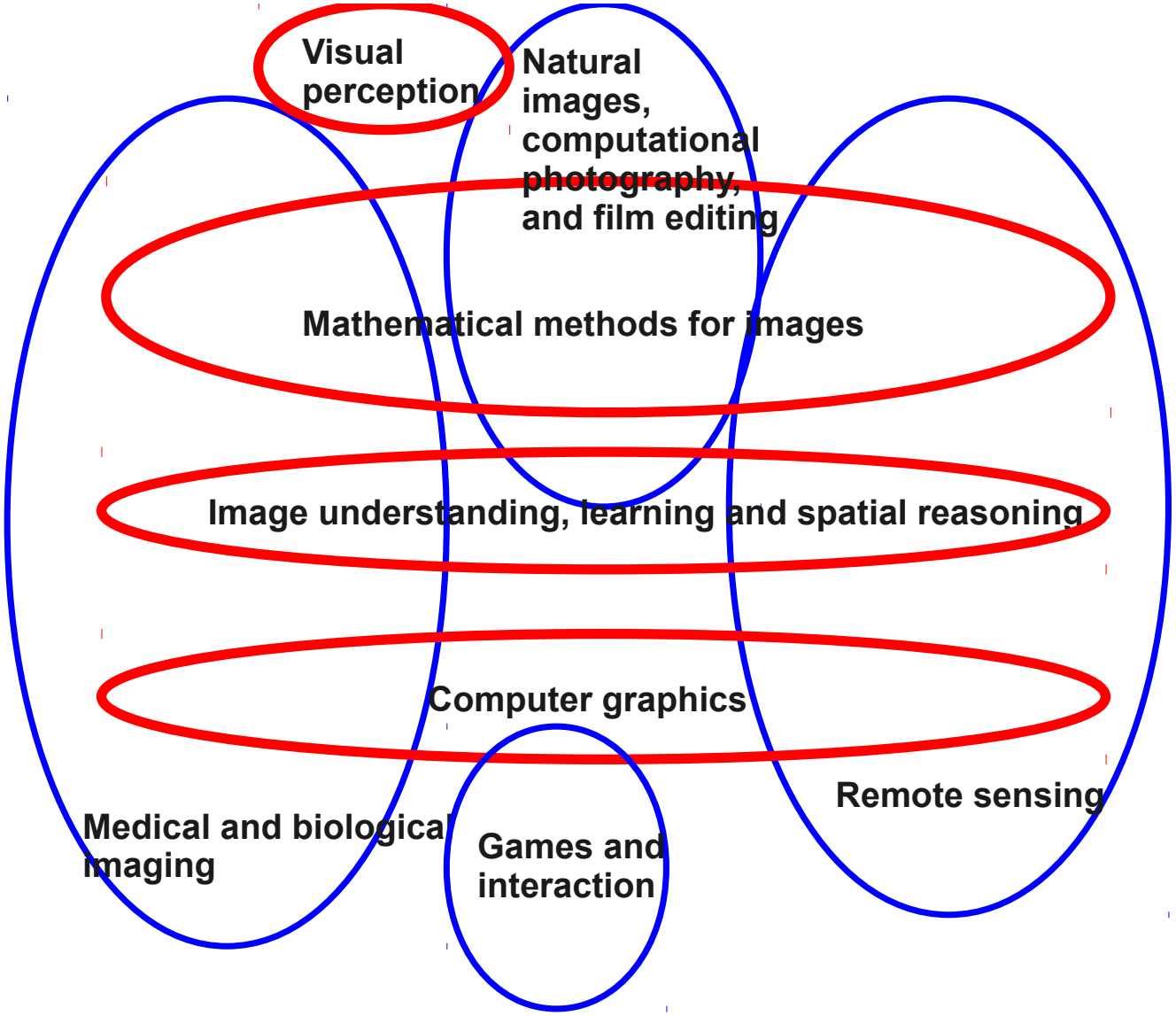
- 12 permanent faculties
- 1 emeritus professor, 2 associate researchers
- 30-35 doctoral candidates
- 3-5 post-docs & engineers
- 1-2 sabbatical fellows

Positioning:

Modelize, analyze, transform, describe, understand, synthesize images, volumes and objects

$\Rightarrow$ models, applications (+ learning)

Research Domains



Methodology

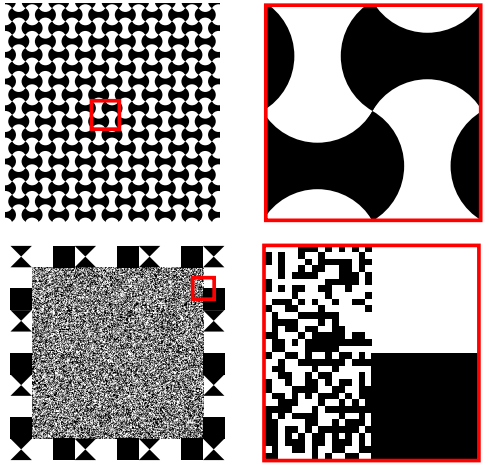
- From raw images to their interpretation...
- Narrow links between theory, methods, algorithms and applications.
- At the crossroad of applied maths, computer sciences, artificial intelligence and engineering $\Rightarrow$ pivotal role for information processing.
- Many interfaces (physics, maths, computer sciences, signal, bio-medical sciences, remote sensing, environment...).
- Strong theoretical bases even for applied projects.
- Rich national & international collaborations.

Web site: `http://perso.telecom-paristech.fr/~bloch/tii/`
Some results & demos: `http://perso.telecom-paristech.fr/~bloch/tii/demos.html`

Mathematical methods for image

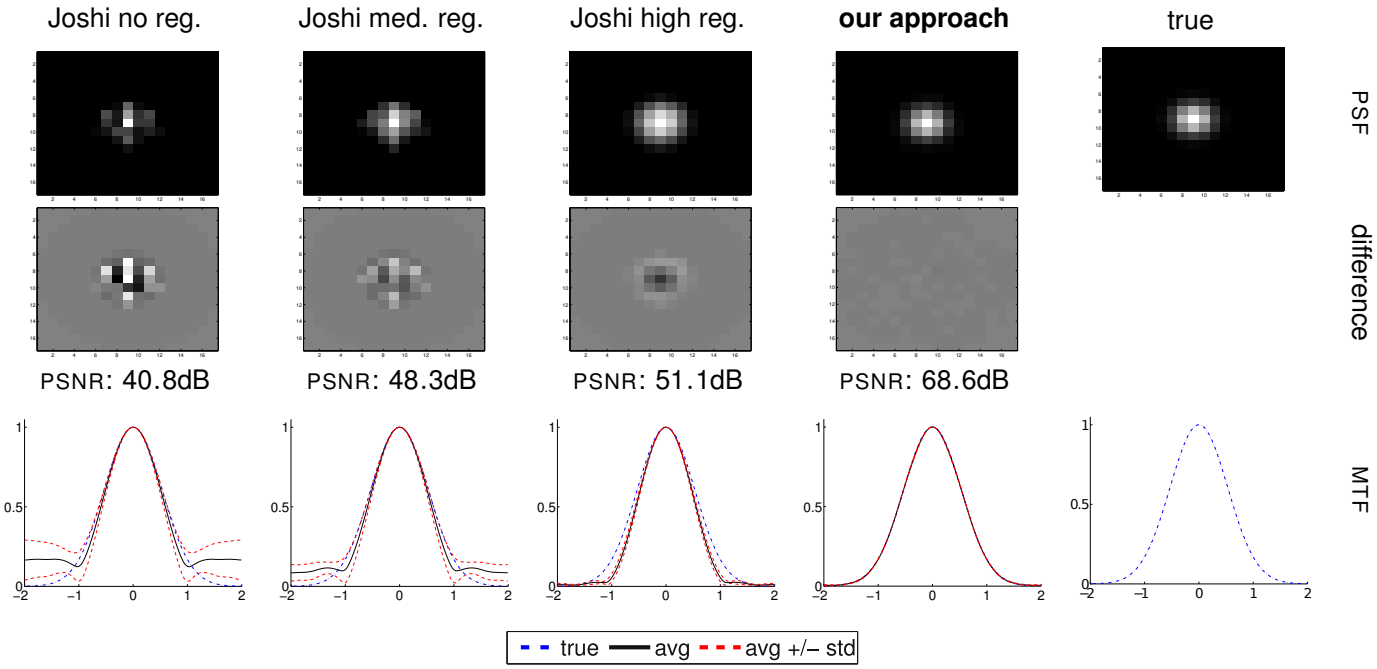
- Mathematical modeling of textures and natural images:
  - stochastic models(Gaussian, seed-grain, sparse),
  - texture synthesis, image and video inpainting,
  - texture analysis and recognition.
- Mathematical modeling of image acquisition and restoration: random sampling, missing and noisy samples, sparse representations, convex and non differentiable optimization.
- Statistical methods for invariant and robust image comparison.
- And also: a contrario methods, Markov random fields, graph-cuts, tracking (particular filters with spatial relationships, multi-objects, multi-images, multi-objets, multi-images, ISA joint lab with Morpho), mathematical morphology.

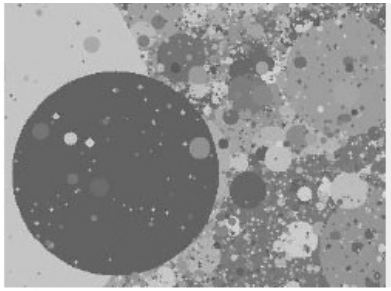
Sub-pixel PSF estimation



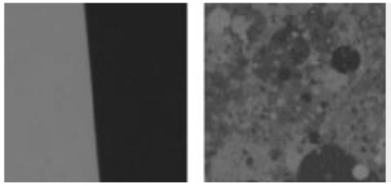
Mire classique
[Joshi et.al. 2008]

Mire quasi-optimale
proposée
[Delbracio et.al. 2012]

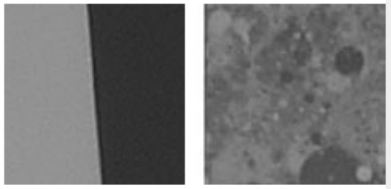




A detail of a target made of a dead leaves pattern, designed to measure Texture Acutance. It is obtained by drawing random shapes that occlude each other in the plane, like dead leaves falling from a tree. The statistics of this model follow the distribution of the same statistics in natural images.

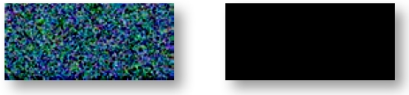


In this example from a DSLR without edge enhancement, sharpness seems equal on edge and on texture. Many details are visible in the texture.

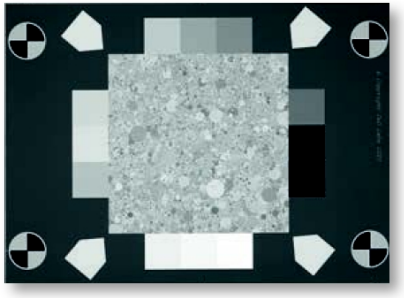


In this second example edges have been digitally enhanced, and the edge looks over-sharp, with visible processing halos ("ringing"). On the texture part, many details have disappeared.

Comment le bruit vient éclaircir une image et diminuer sa netteté.



Nouvelle mire d'analyse des textures.



Nous mesurons le niveau de bruit de fond (en dB) en position « réduction de bruit standard » de 400 Iso à la sensibilité maximale. Plus le chiffre de l'axe en dB est faible (10 dB par exemple) plus le bruit est perceptible. Malheureusement, cette réduction du bruit est souvent associée à la perte de détails dans les textures, nous analysons dorénavant la préservation des textures sur des zones peu contrastées de l'image.
Tout défaut de lissage ou de suraccentuation est automatiquement détecté. Ce nouveau test (DxO) associe une mire à faibles contrastes appelée « feuilles mortes » et un logiciel d'analyse spécifique. Un produit idéal propose un niveau de bruit faible et un niveau de texture élevé.

DxO - Fnac

Video Inpainting

Best student paper (google prize) CVMP 2013

Video Inpainting

Best student paper (google prize) CVMP 2013

Texture synthesis using sparse representations

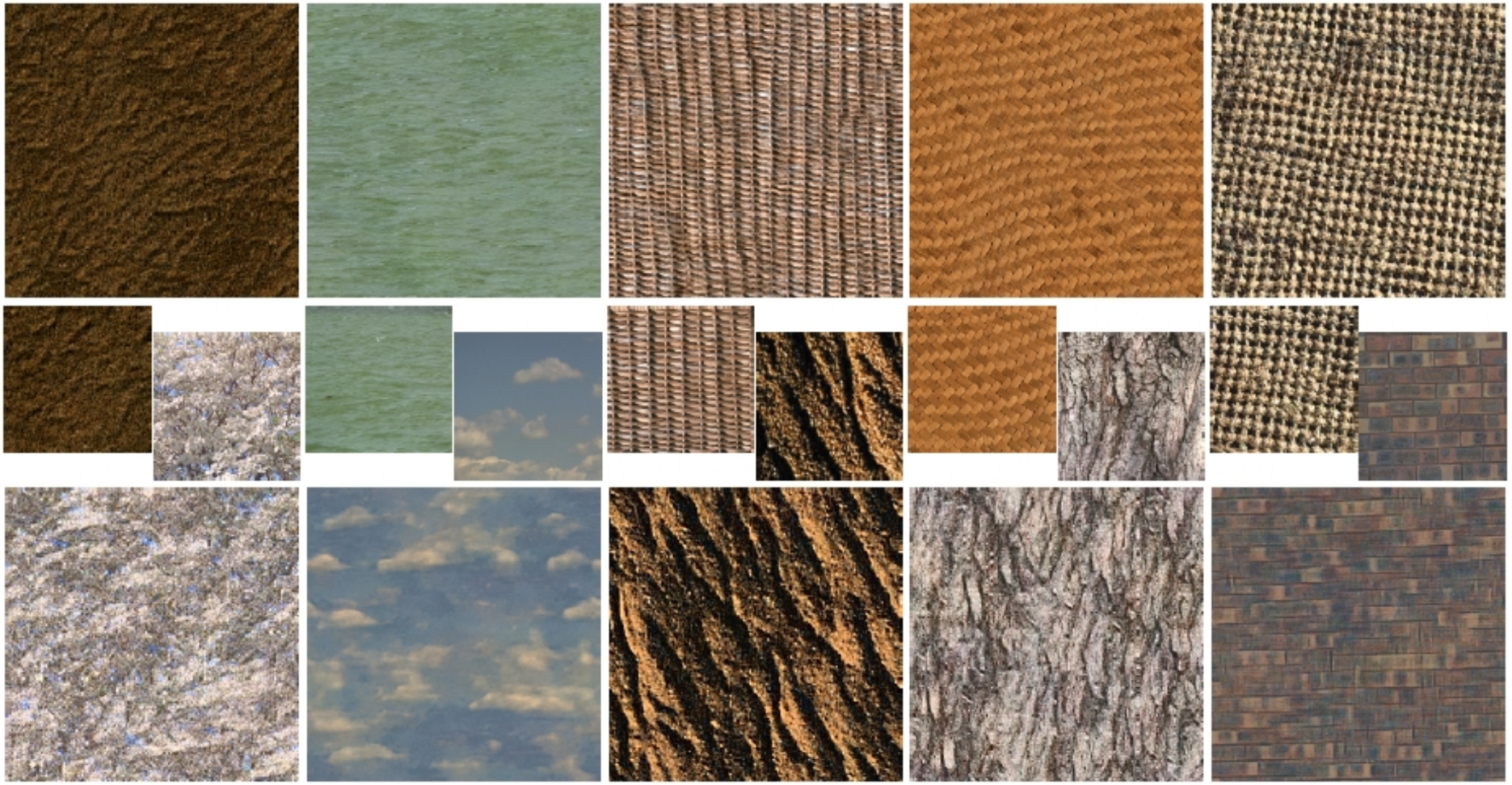
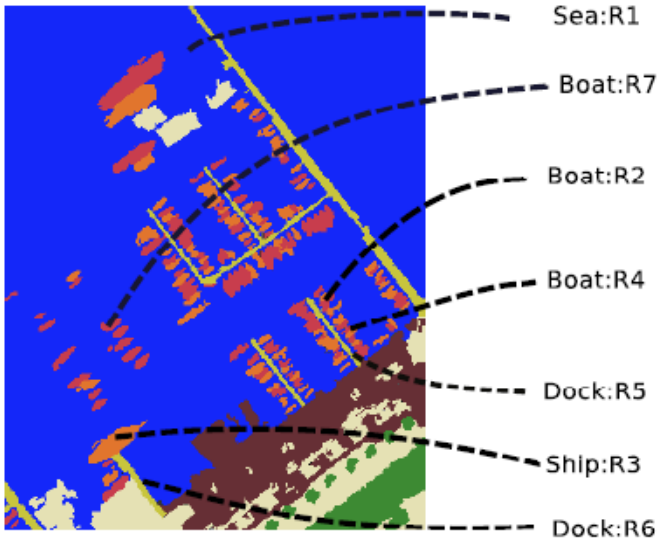


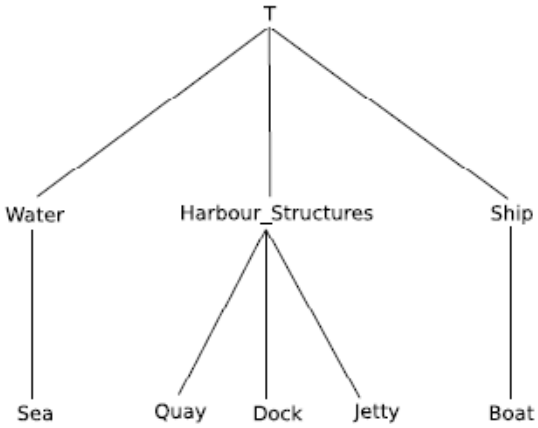
Image understanding, learning and spatial reasoning

- Modeling spatial relations (mathematical morphology & fuzzy sets).
- Ontologies, graphs and conceptual graphs for spatial reasoning and image understanding, morpho-logic.
- Integrated into models and segmentation methods for structural pattern and object recognition.
- Learning, classification, annotation & data mining in image databases (ranked 1st at ImageCLEF 2013 - context dependant models).
- And also: sequential segmentation, CSP, inexact graph matching, conflict & belief functions, ontologies for annotation, graph kernels, color perception, indexing & mining in fingerprints databases (ISA).

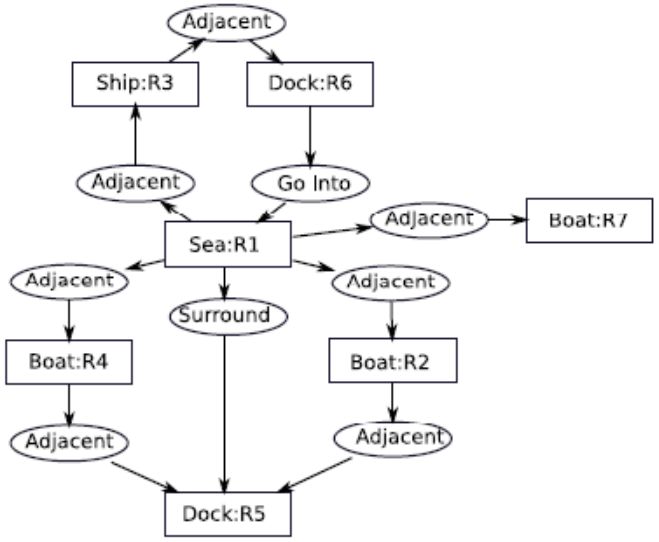
(a) Example image.



(b) Labeled image: The blue regions represent the sea, the red and orange represent ships or boats and the yellow regions represent the docks.

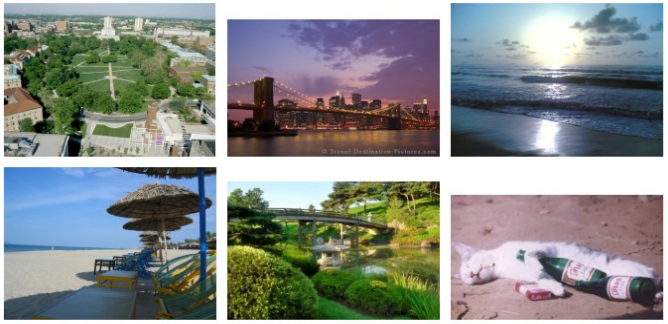


(c) Concept hierarchy T_C in the context of harbors.



(d) Conceptual graph representing the spatial organization of some elements of Figure 5.8(b).

ImageCLEF 2013: Scalable Concept Image Annotation

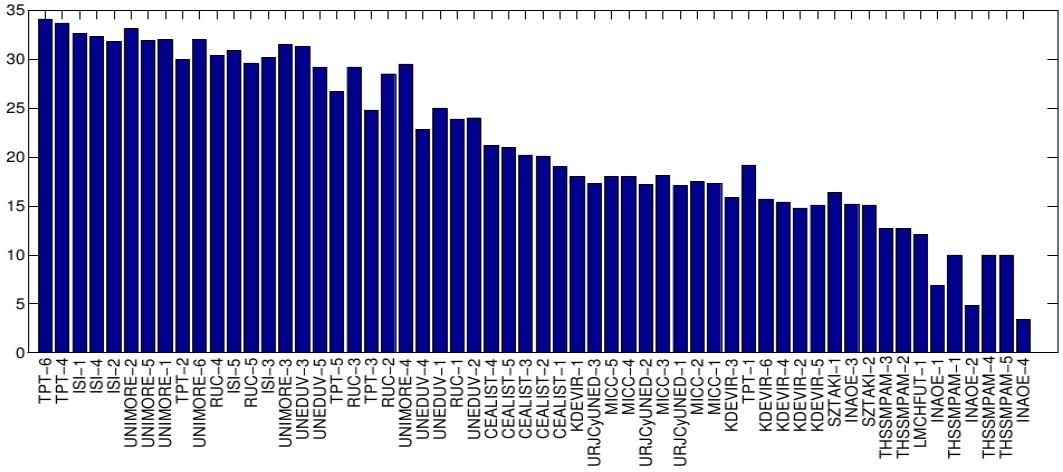


boat cityscape cloudless
nighttime outdoor reflection
sea silhouette sky sun
sunrise/sunset water

aerial countryside
daytime forest
grass outdoor
park plant sky
soil tree

58 runs, 13 participants:

-TPT: CNRS - Telecom ParisTech, **France**.
-ISI: Tokyo U., **Japan**.
-UNIMORE: U. of Modena, **Italy**.
-RUC: Renmin U. of **China**.
-UNEDUV: National U. of Distance Education at **Spain**.
-CEALIST: CEA, **France**.
-KDEVIR: Toyohashi U.of Technology, **Japan**.
-URJCyUNED: King Juan Carlos U., **Spain**.
-MICC: Florence U. in **Italy**.
-SZTAKI: Hungarian Academy of Sciences.
-INAOE: National Institute of Astrophysics, Optics and Electronics in **Mexico**.
-THSSMPAM: Tsinghua U., Beijing, **China**.
-LMCHFUT: Hefei U. of Technology, **China**.



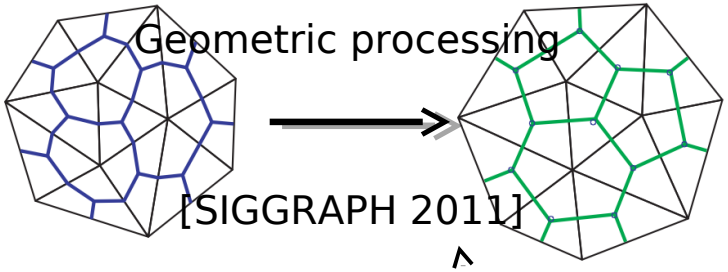
Official F-Scores: http://imageclef.org/2013/photo/annotation/results
References:

-Hichem Sahbi. CNRS – TELECOM ParisTech at ImageCLEF 2013 Scalable Concept Image Annotation Task: Winning Annotations with Context Dependent SVMs. In ImageCLEF 2013.
-Hichem Sahbi and Xi Li. Context-Based Support Vector Machines for Interconnected Image Annotation ("The Saburo Tsuji" Best Regular Paper Award). In the Asian Conference on Computer Vision, ACCV 2010.

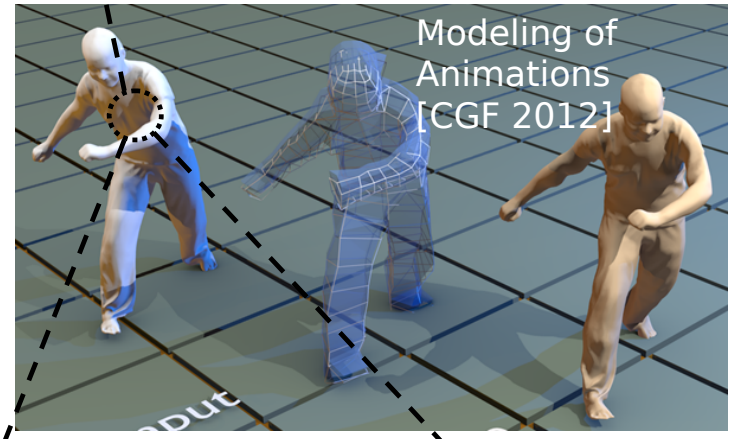
Computer graphics

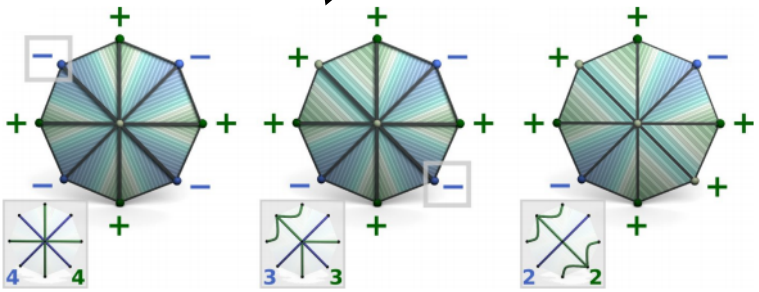
- 3D modeling:
  - triangulations & dual spaces,
  - fast processing,
  - geometrical & topological processing.
- Image synthesis & visualization:
  - visualization of large simulations,
  - fast global lighting.
- Vision & imagery:
  - visual search engine,
  - interactive panorama editing.
- Strong interactions with the other research topics of the team.

Geometry

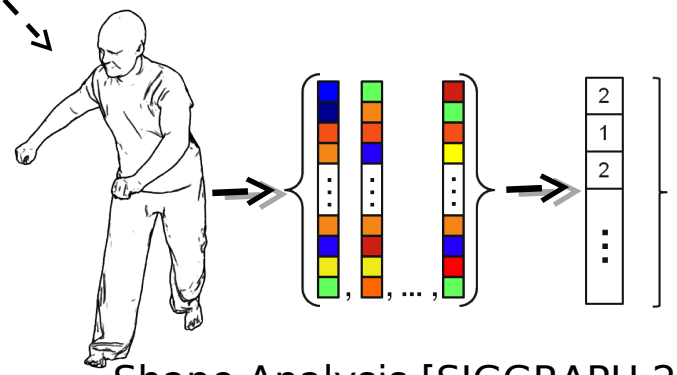


Modeling in Computer Graphics



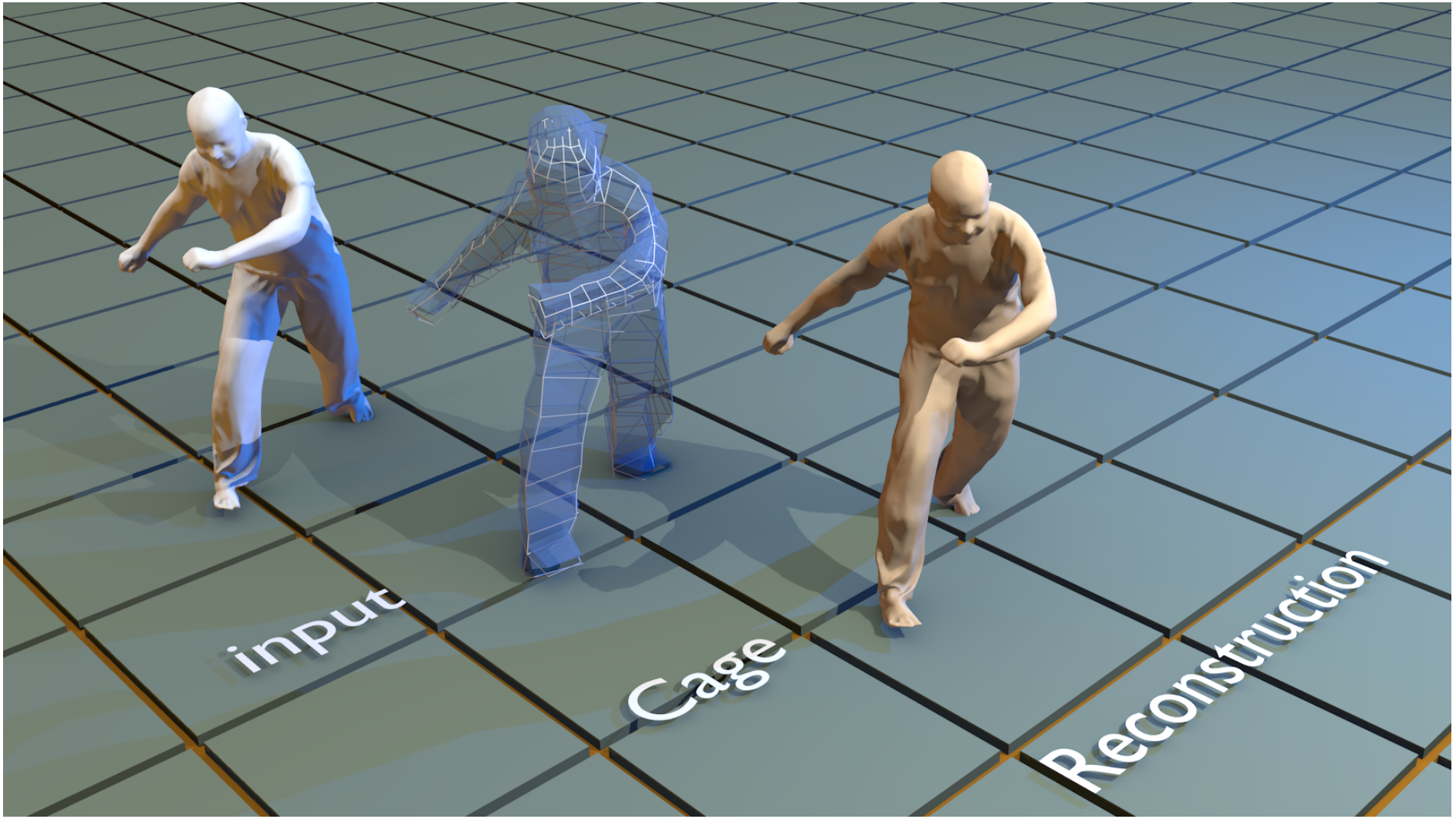


Topological processing [IEEE Vis 2012]

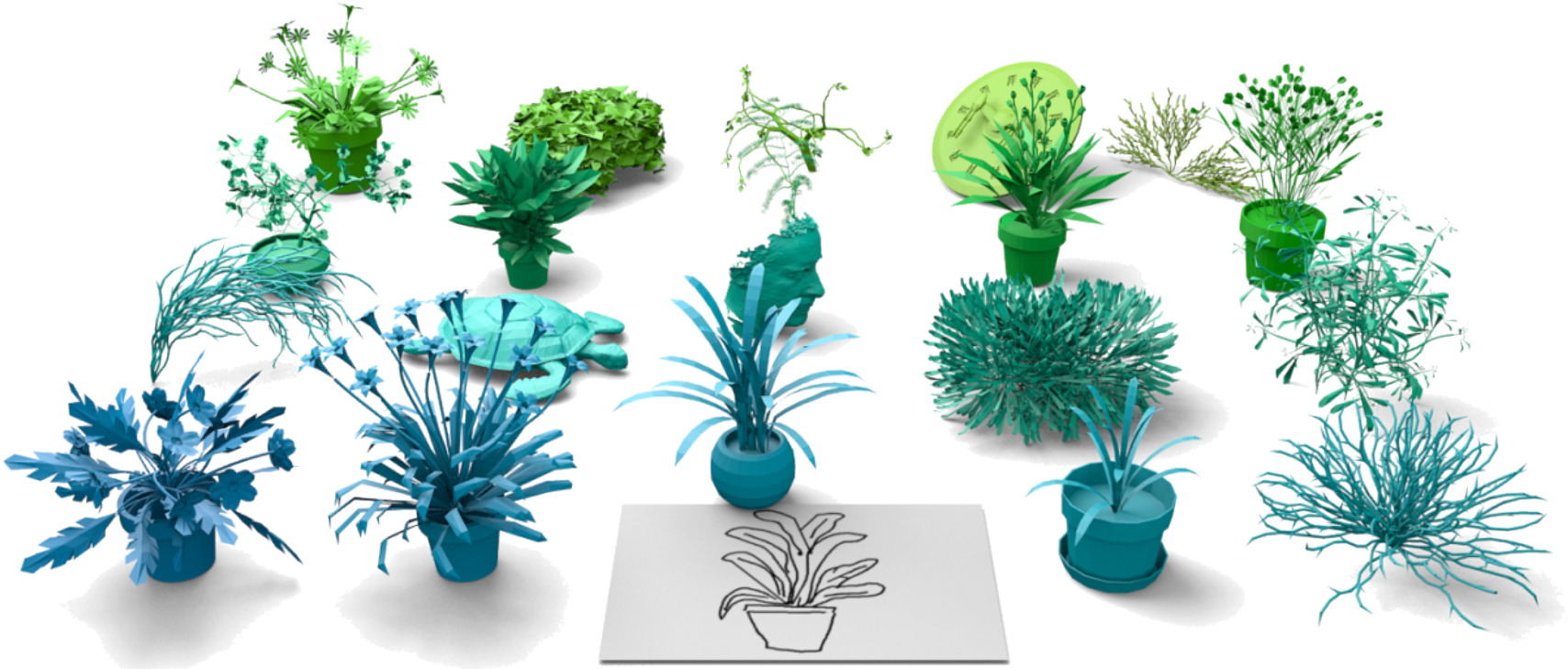


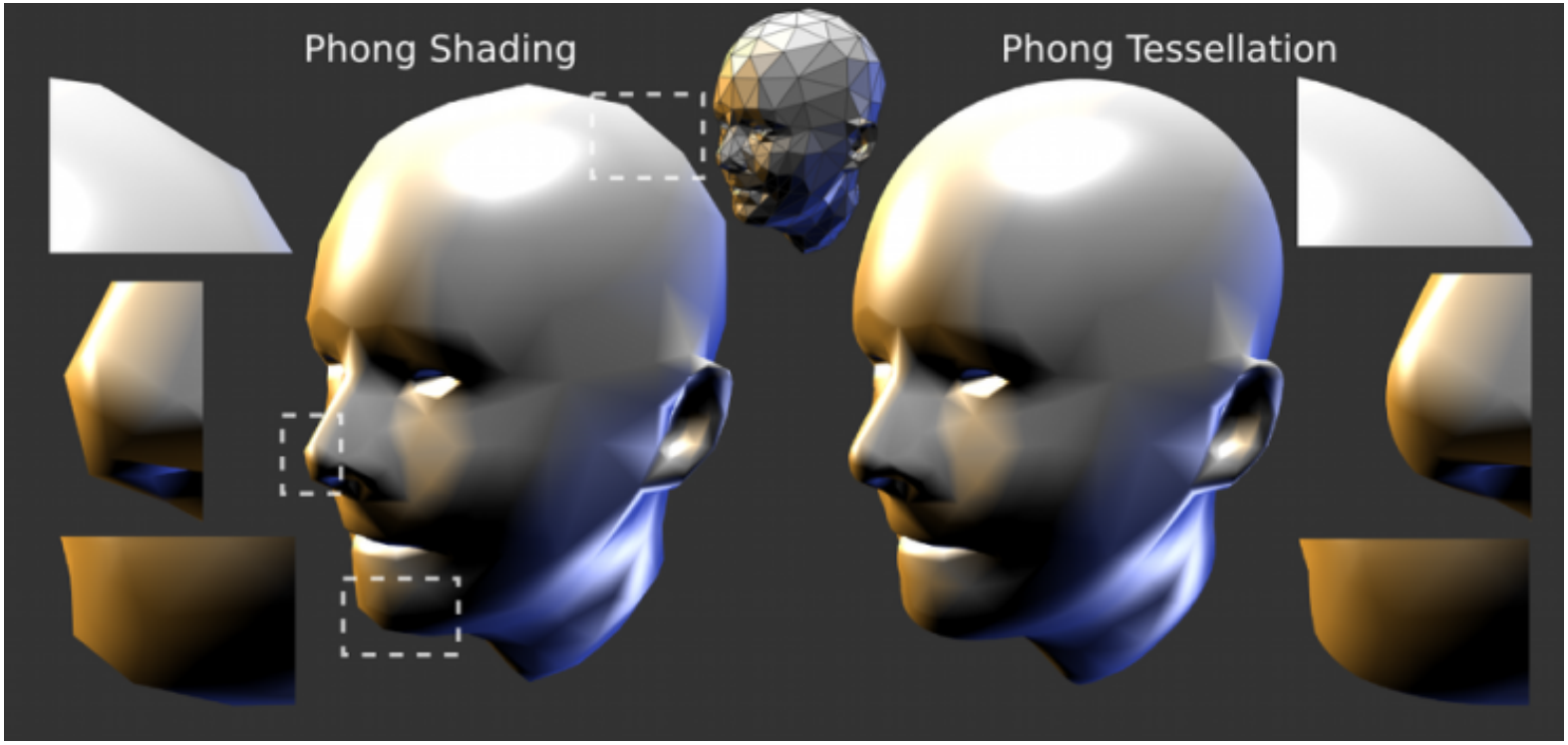
Shape Analysis [SIGGRAPH 2012]

Animated shape analysis using cages



2D/3D visual mining

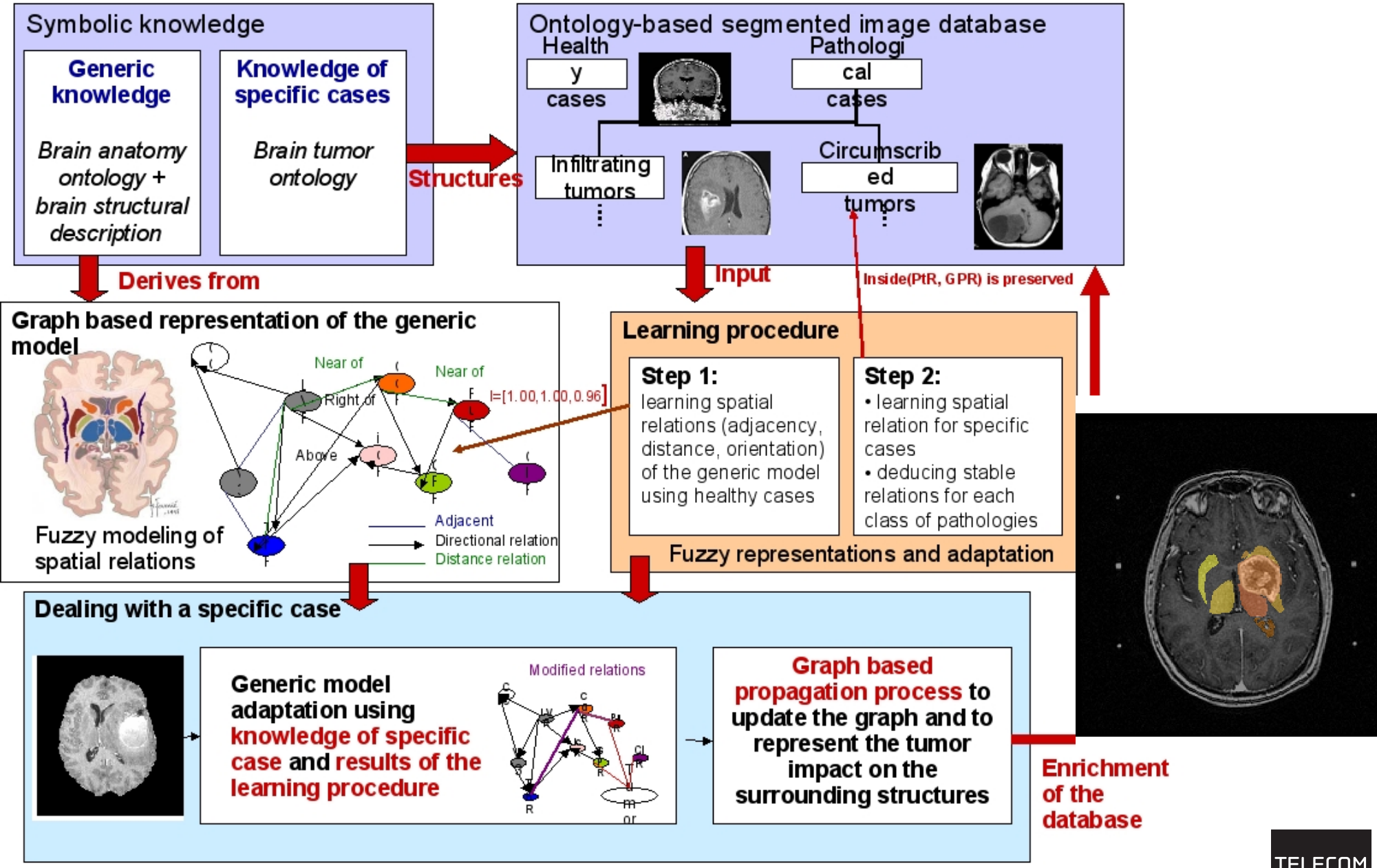


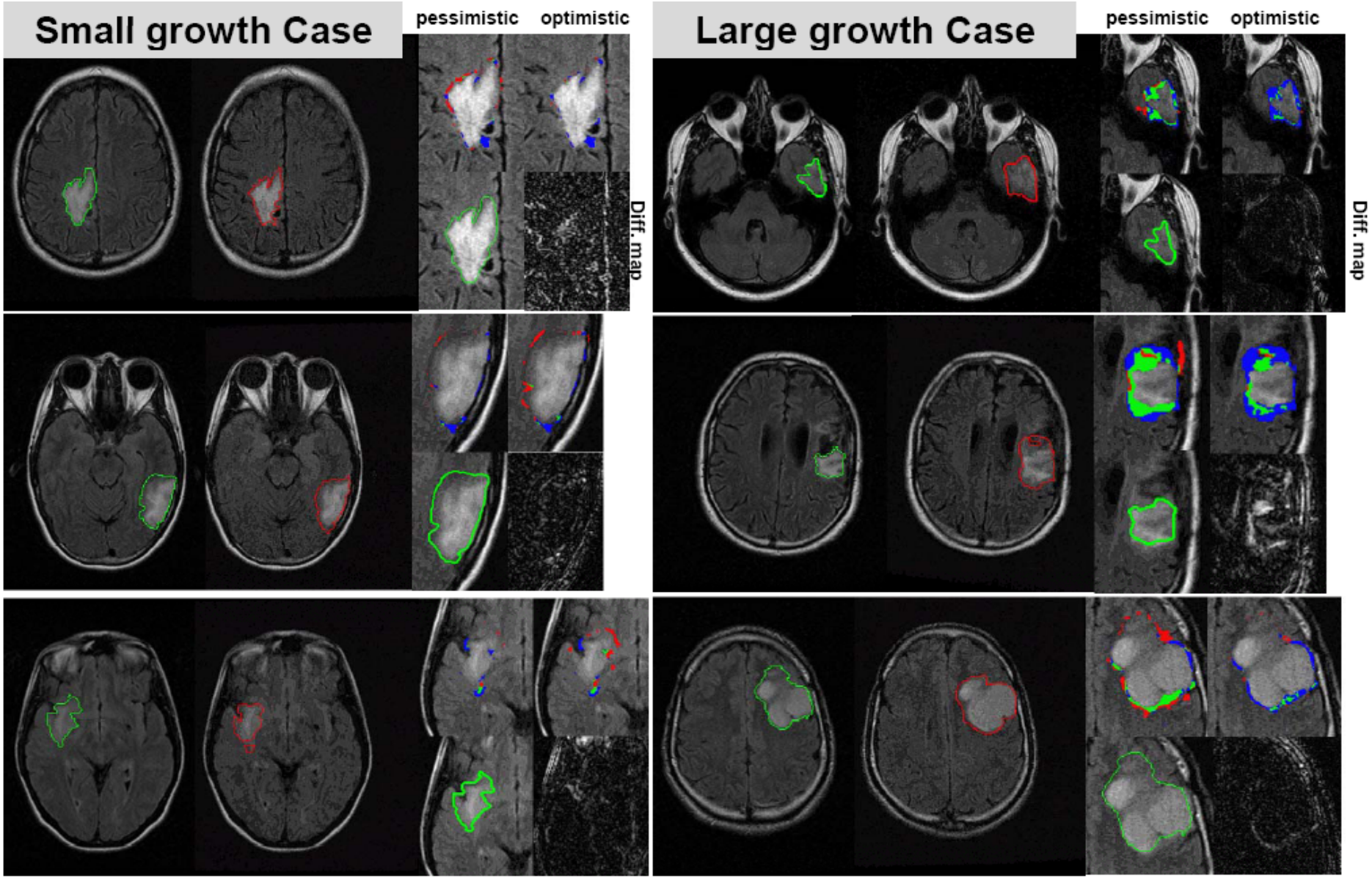


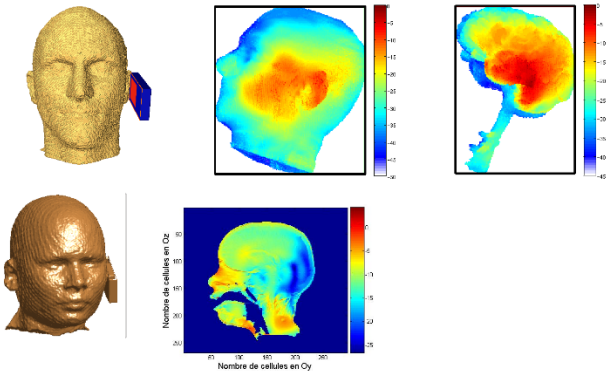
Used in professional 3D engines: Unreal Engine, Cry Engine and Unity, in recent games (Deus Ex, Splinter Cell, Metro 2033...), in the 3DMark benchmark.

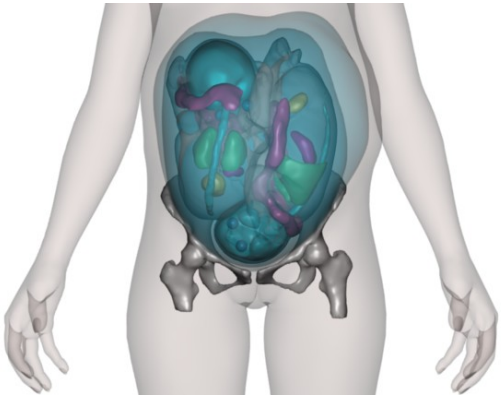
Medical and biological imaging

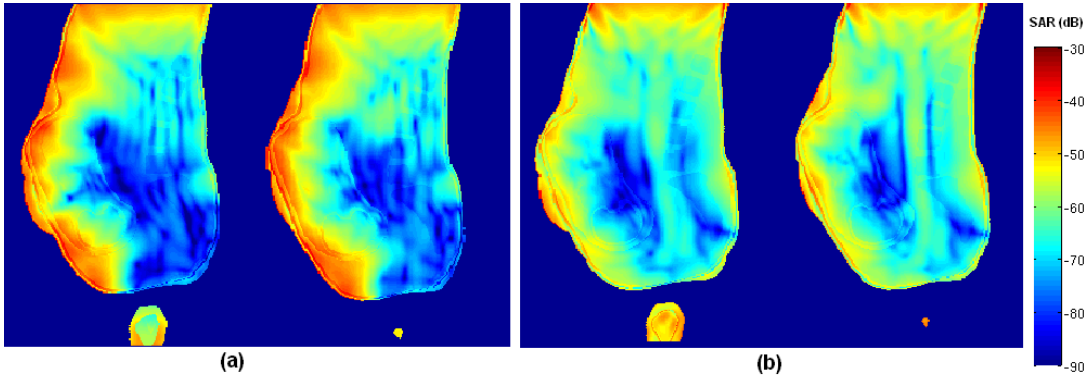
- Modeling anatomical, in particular structural, knowledge (spatial relationships).
- Fusion with individual information.
- Model based segmentation and recognition (anatomical & pathological structures).
- Longitudinal follow-up.
- Realistic human body modeling (dosimetry, aid to diagnosis, accidentology...).
- Strong interactions with the previous research fields.
- Associate researcher: C. Adamsbaum (prof. Kremlin-Bicêtre, Paris Sud).
- Joint Lab with Orange Labs: WHIST.
- And also: mammography (CAD, dose), retinal imaging (AO, OCT), thorax & abdomen imaging (CT + TEP / MRI + TEP for oncology), vascular imaging (CT, AO), antenatal imaging (US & MRI), elastography, very low dose X-ray imaging, biological image acquisition and processing (2D & 3D particle tracking, sparse representations).

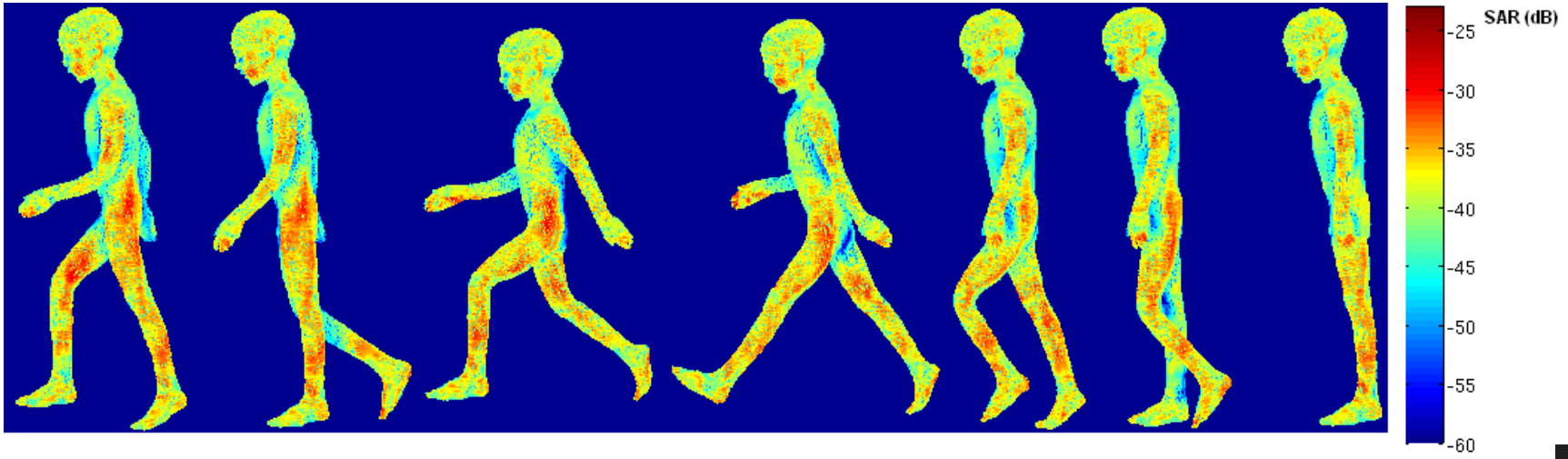

Symbolic knowledge
Generic knowledge
Brain anatomy ontology + brain structural description
Knowledge of specific cases
Brain tumor ontology
Structures
Ontology-based segmented image database
Health y cases
Pathologi cal cases
Infiltrating tumors
Circumscrib ed tumors
Derives from
Input
Inside(PtR, GPR) is preserved
Graph based representation of the generic model
Near of
Near of
Right of
Above
I=[1.00,1.00,0.96]
Adjacent
Directional relation
Distance relation
Fuzzy modeling of spatial relations
Learning procedure
Step 1:
learning spatial relations (adjacency, distance, orientation) of the generic model using healthy cases
Step 2:
• learning spatial relation for specific cases
• deducing stable relations for each class of pathologies
Fuzzy representations and adaptation
Dealing with a specific case
Generic model adaptation using knowledge of specific case and results of the learning procedure
Modified relations
Graph based propagation process to update the graph and to represent the tumor impact on the surrounding structures
Enrichment of the database


Small growth Case
pessimistic
optimistic
Diff. map
Large growth Case
pessimistic
optimistic
Diff. map


Nombre de cellules en Oz
Nombre de cellules en Oy

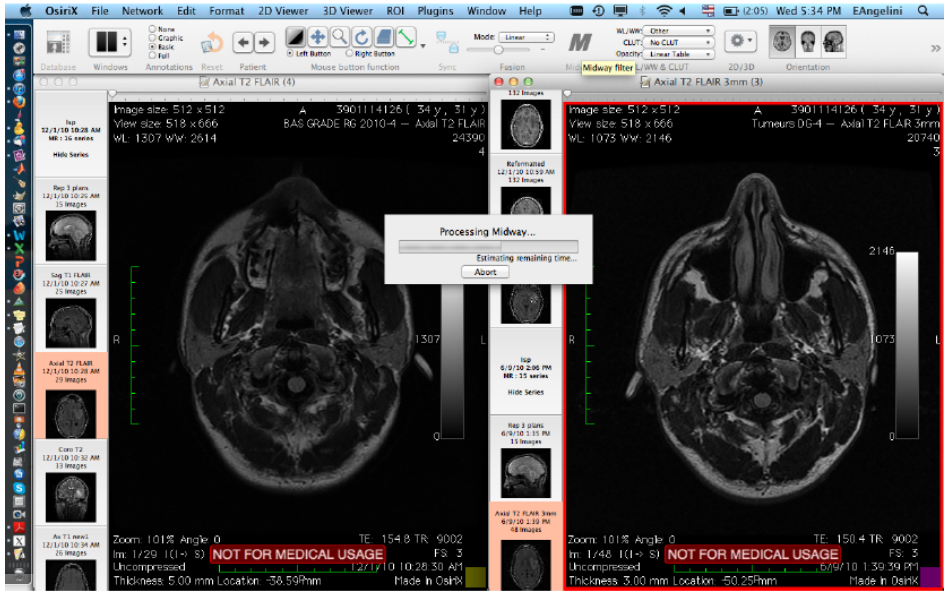


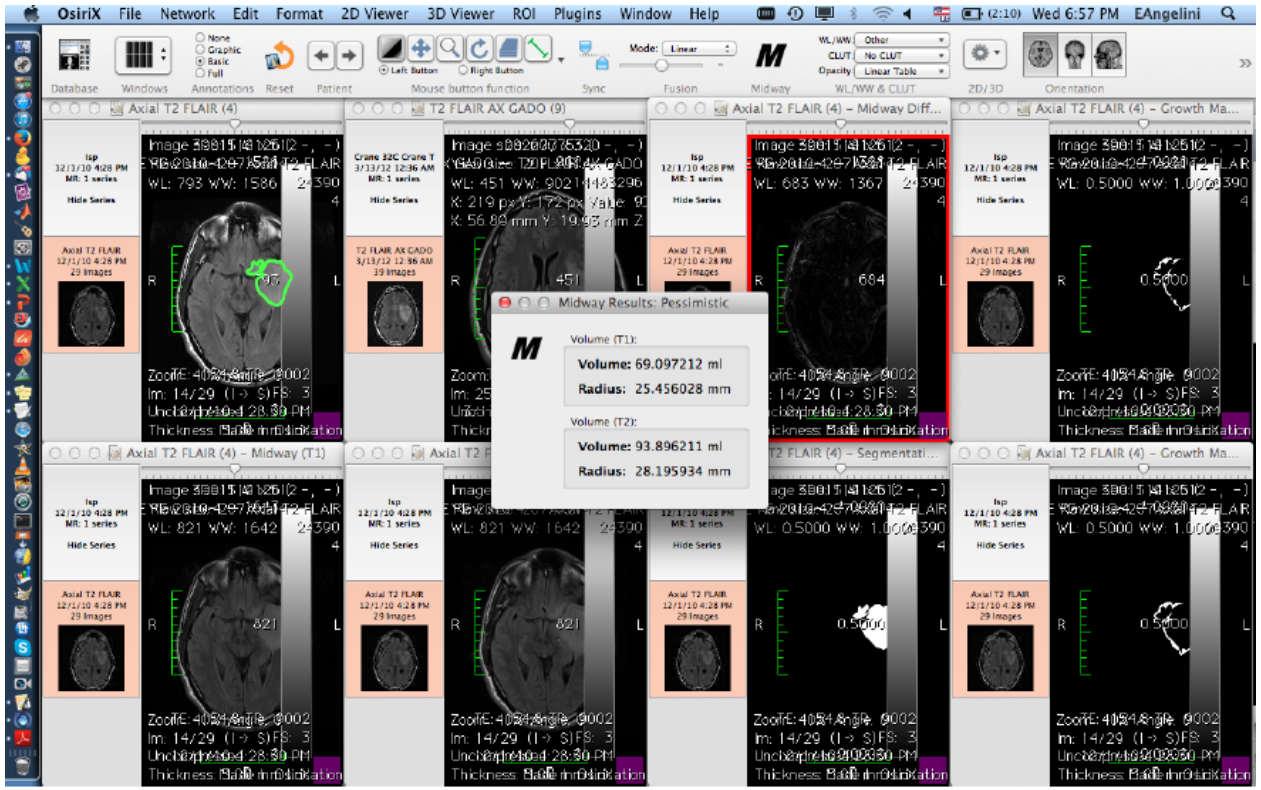

SAR (dB)
-30
-40
-50
-60
-70
-80
-90
(a)
(b)


SAR (dB)
-25
-30
-35
-40
-45
-50
-55
-60

Fetal and Mother Numerical Models (FEMONUM)

Home - Publications - Download Page - About Us - FEMONUM Community - Contact


OsiriX File Network Edit Format 2D Viewer 3D Viewer ROI Plugins Window Help
Axial T2 FLAIR (4)
Axial T2 FLAIR 3mm (3)
Processing Midway...
Estimating remaining time...
Abort
NOT FOR MEDICAL USAGE
NOT FOR MEDICAL USAGE

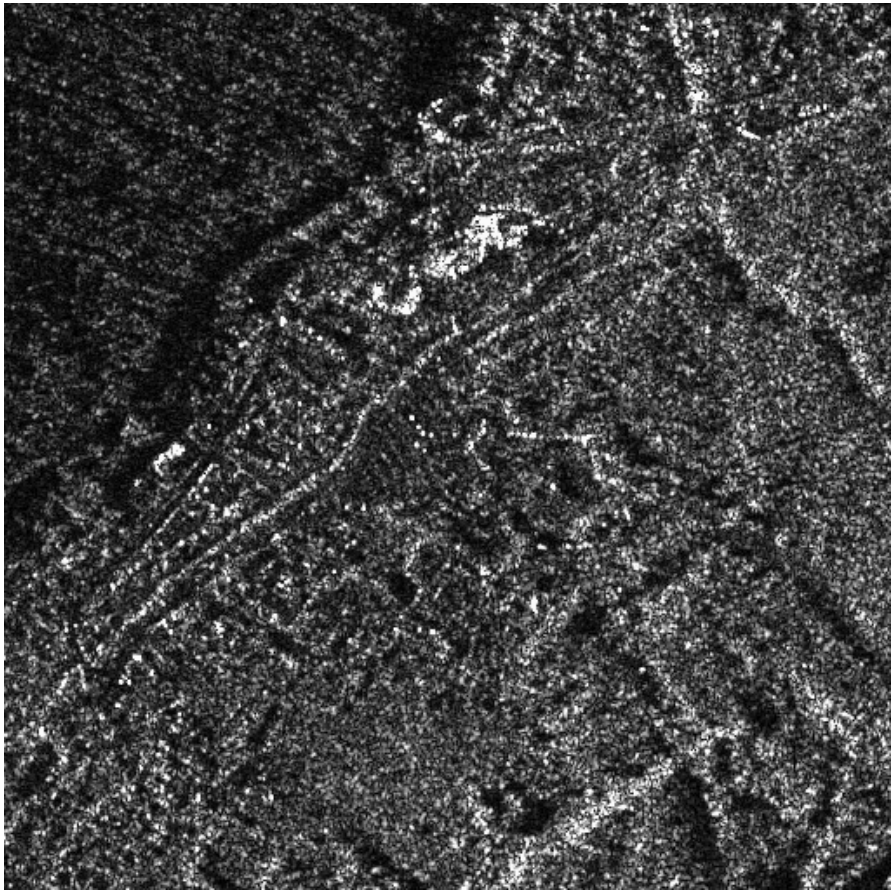

OsiriX File Network Edit Format 2D Viewer 3D Viewer ROI Plugins Window Help
Axial T2 FLAIR (4)
T2 FLAIR AX GADO (9)
Axial T2 FLAIR (4) – Midway Diff...
Axial T2 FLAIR (4) – Growth Ma...
Midway Results: Pessimistic
Volume (T1):
Volume: 69.097212 ml
Radius: 25.456028 mm
Volume (T2):
Volume: 93.896211 ml
Radius: 28.195934 mm
Axial T2 FLAIR (4) – Midway (T1)
Axial T2 FLAIR (4) – Segmentati...
Axial T2 FLAIR (4) – Growth Ma...

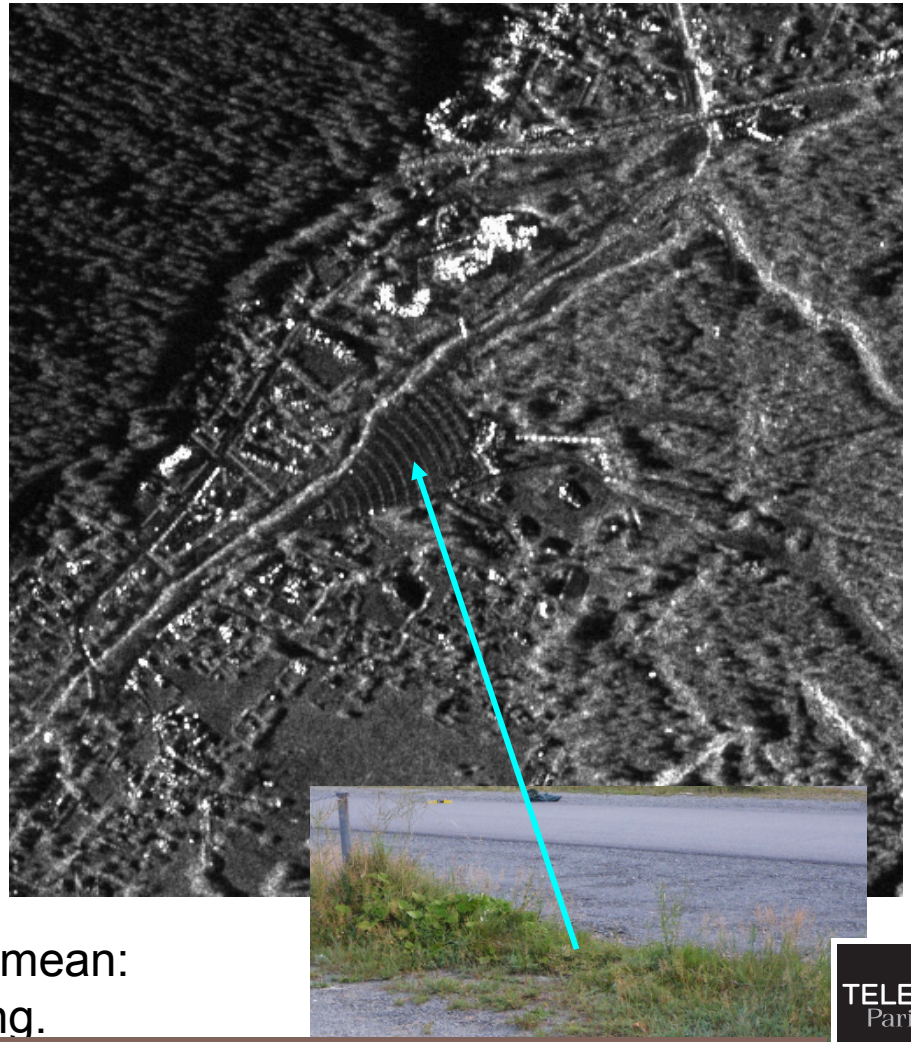
Remote sensing

- SAR radar parameter estimation (polarimetry, interferometry).
- Modeling statistics of radar images with Meijer transform, application to change detection.
- Temporal or multi-temporal series analysis (optical / radar fusion). Statistical modeling (new SIFT descriptors for SAR), change detection applications.
- SWOT (NASA / CNES) Project - two experts for hydrological network detection in the Science Definition Team.
- Joint Laboratory LTCI-CNES-DLR : COC (06/05 - 06/10).
- And also: 3D model generation, stereovision, artefact detection & suppression in soil moisture and ocean salinity data, visualization & navigation, information extraction & classification for natural catastrophies.

SAR temporal stacks

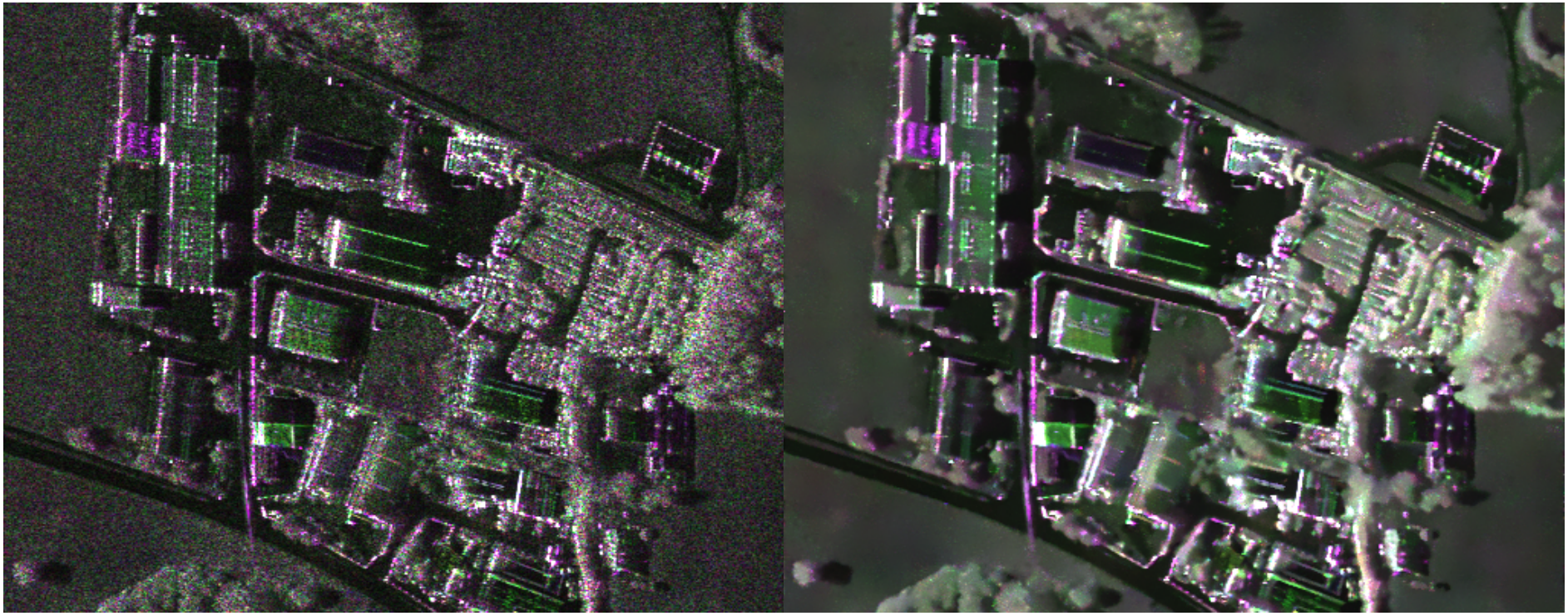
1 km





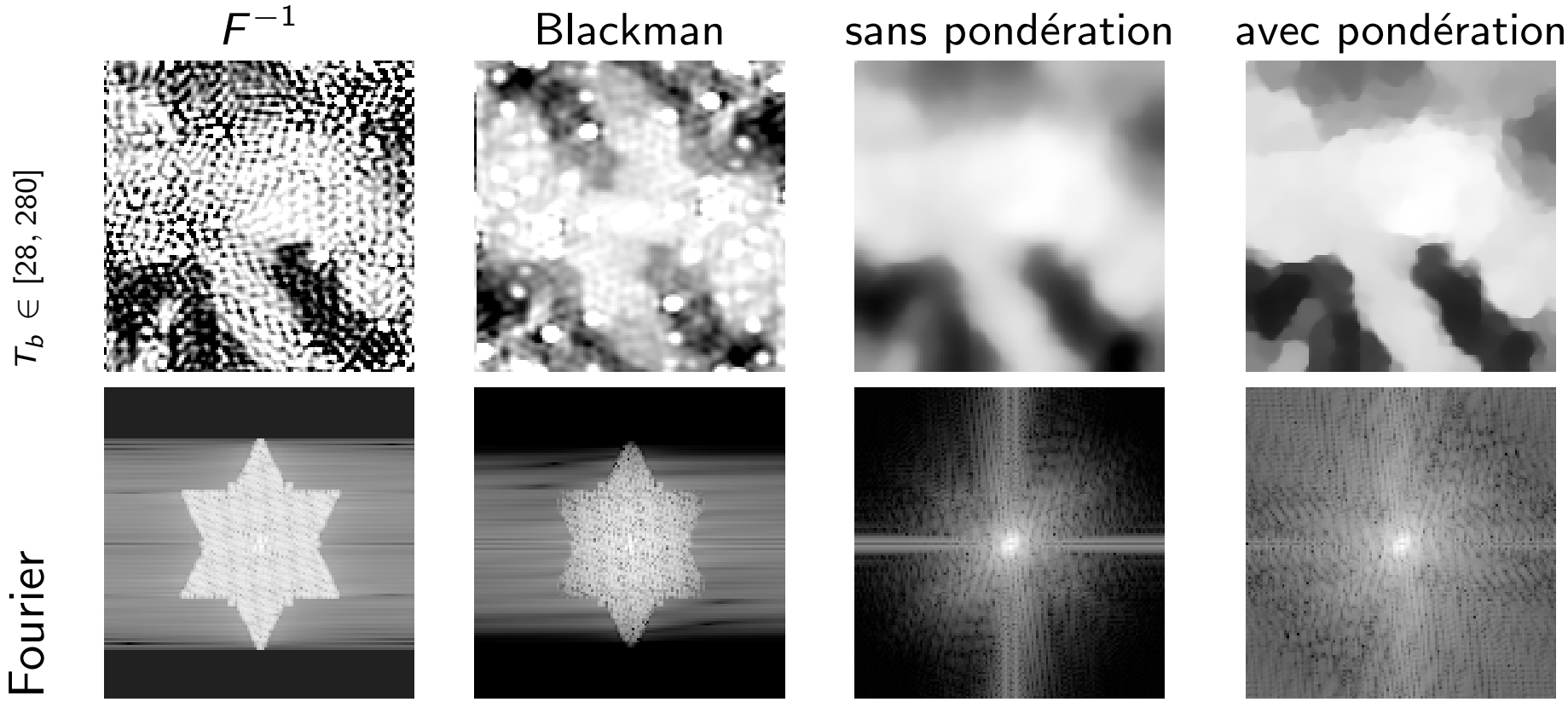
Sub-pixel registration +geometrical mean: highlighting fine details on the parking.

SAR image processing- NL-SAR



Best thesis award: Charles Deledalle (Prix de thèse Signal Image Vision 2012)
Best paper of IEEE Transactions on Geoscience and Remote Sensing 2015

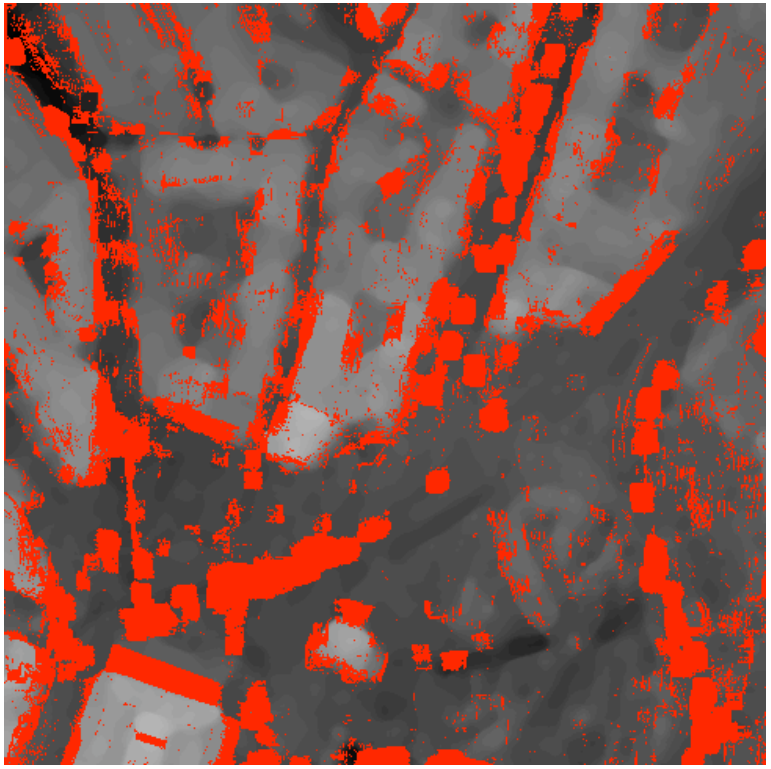
Outliers separation in SMOS images: TV-L1-L2 optimization



Fine basis stereoscopy stability

Paire stéréo

Gris = luminance



Gris = disparité

Rouge = non-validé (indécidable)